Elliott Bay/Duwamish Restoration Program:
Year 2 Intertidal Habitat Projects Monitoring Report

September 2003

Report prepared for the Elliott Bay/Duwamish Restoration Program Panel

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INTRODUCTION

Restoration Sites

This report describes Year 2 monitoring efforts and results for two restoration projects in the lower Duwamish River Estuary. The projects were constructed in 2000, fulfilling part of a 1991 consent decree between the City of Seattle, Metro (now King County Department of Natural Resources) (DNR), and natural resource trustees[1]. The projects' construction and monitoring have been under the sponsorship and guidance of the Elliott Bay/Duwamish Restoration Program (EBDRP) Panel of Managers, comprised of the City of Seattle, King County DNR, and the natural resource trustees.

Monitoring efforts in 2002 for the EBDRP were limited to two of four restoration sites described in the monitoring plan (EBDRP 2000): Hamm Creek Estuary and Herring's House (formerly Seaboard Lumber) restoration sites (Figure 1). Construction on the North Winds Weir restoration site began in December 2002, and monitoring is expected to commence in early 2003. Construction at the Kenco Marine site has not been initiated, but will begin pending finalization of environmental compliance and permitting processes.

All surveys were performed according to guidance in the Intertidal Habitat Projects Monitoring Program (EBDRP 2000) monitoring plan, unless otherwise specified.

Reference Sites

Hamm Creek Estuary

The location and number of reference areas vary for each restoration site, based on the availability of similar sites and requirements for each monitoring criteria. For Hamm Creek Estuary, three reference sites were used (Figure 2). A natural area forming a peninsula (near a small creek adjacent to the Turning Basin #3) was used as the reference site for both fish and bird surveys. Fish were surveyed at a point just north of this site, while birds were surveyed in the estuary in the northern part of the peninsula. A small marsh on the eastern bank of the Duwamish River, across from North Winds Weir, was used as a reference site for marsh vegetation. The third reference area, for sediments and macroinvertebrates, consisted of a small fringe marsh located along the shoreline adjacent to the study area, just up- and downstream of the restoration site.

[1] National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, Washington State Department of Ecology, the Muckleshoot Indian Tribe, and the Suquamish Tribe.

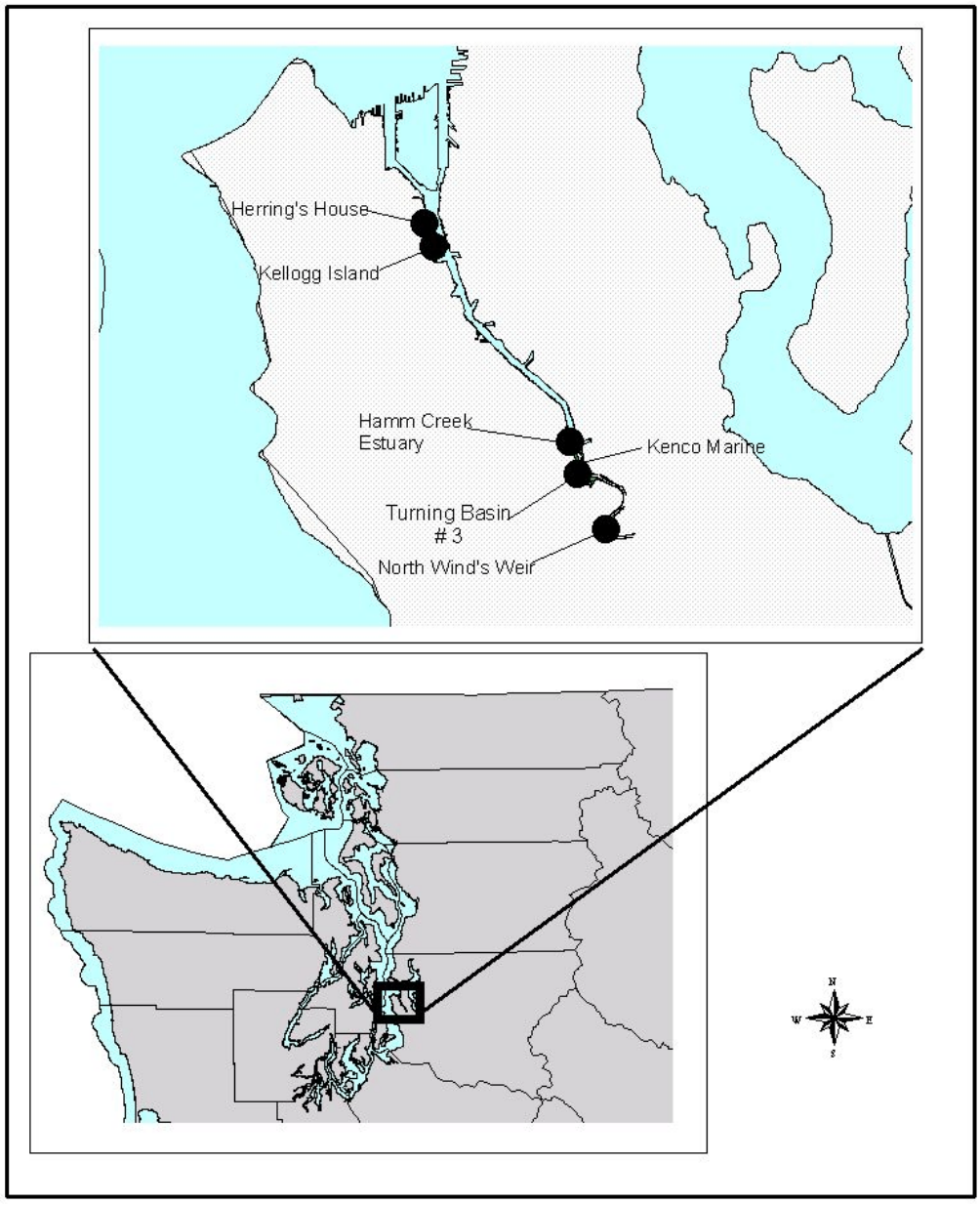

Figure 1. Location of Duwamish River Estuary restoration sites monitored in 2001 and 2002.

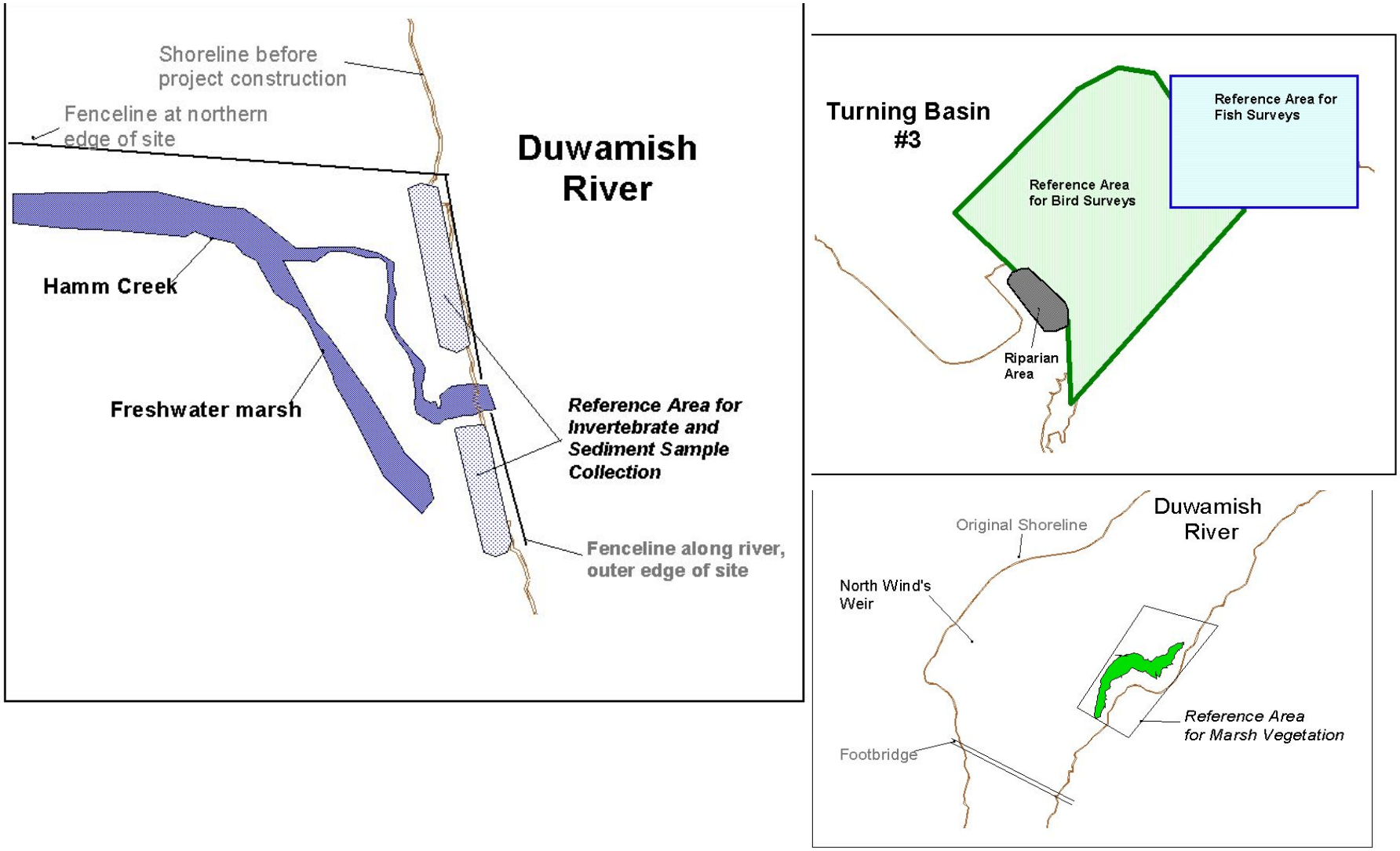

Figure 2. Location of reference sites for Hamm Creek Estuary restoration sites, in 2001 and 2002.

Herring's House

For Herring's House, three reference sites were used (Figure 3). The reference site for fish sampling was a beach on the eastern shore of Kellogg Island, near the bend at the midpoint of the island. The northwest edge of Kellogg Island (directly across from the mouth of Puget Creek) was used as the reference site for bird surveys. The third reference site, for marsh vegetation, sediments and macroinvertebrates, has a small area of naturally occurring stands of Lyngby's sedge (*Carex lyngbyei*) and bulrush (*Scirpus validus*), and was located just upstream of the Herring's House restoration site.

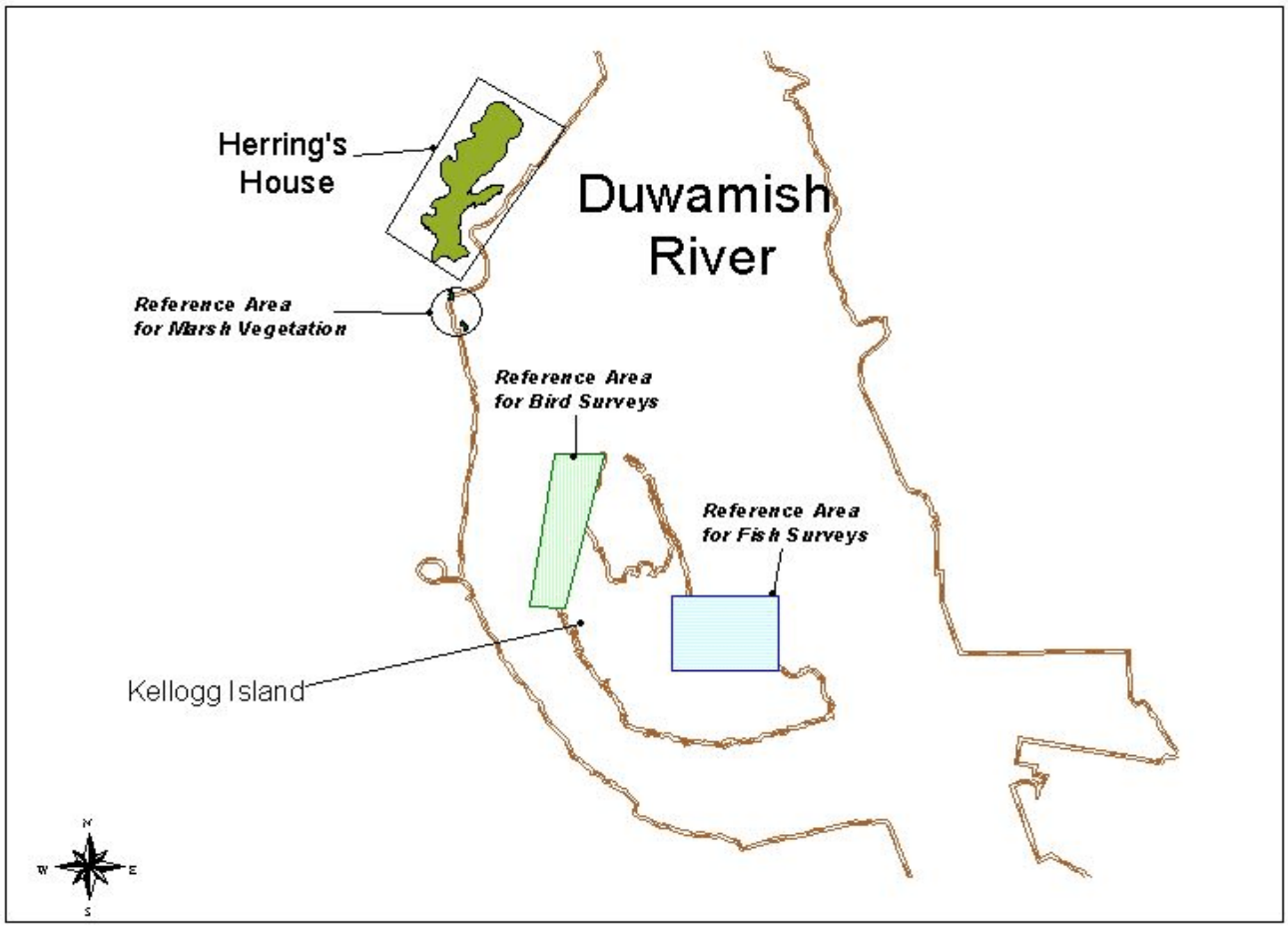

Figure 3. Location of reference sites for Herring's House restoration sites, in 2001 and 2002.

Monitoring Criteria

For the first two years of monitoring, 13 criteria were grouped under 10 different physical and biological categories (Table 1). The following sections present, for each criterion, the methods, results, and a discussion of the 2002 surveys.

Table 1. Physical and biological success criteria monitored at the Elliott Bay/Duwamish Restoration Program Sites (from EBDRP 2000).

Physical Success Criteria	Biological Success Criteria
Intertidal Area	Marsh Vegetation Establishment
Tidal Regime	*Marsh vegetation area*
Slope Erosion	*Species composition*
Sediment Structure	*Plant vigor*
Sediment Quality	Riparian Vegetation Establishment
	Areal extent and invasive plant coverage
	Survival
	Bird Use
	Fish Access/Presence
	Invertebrate Prey Resource Production

PHYSICAL CHARACTERISTICS

Intertidal Area (Physical Success Criterion 1) *Total restored area between an elevation of +12.0 ft Mean Low Low Water (MLLW) and -2.0 ft MLLW will be at least 90% of the target intertidal elevation for each site. Target intertidal areas for the Hamm Creek Estuary and Herring's House sites are 4,047 m^2 (1.0 acre) and 8,094 m^2 (2.0 acres), respectively.*

Methods

The Hamm Creek Estuary and Herring's House sites were surveyed in fall and winter 2002 using Nikon[2] Total Station and standard surveying techniques (Harrelson et al. 1994). The precision of the Hamm Creek Estuary and Herring's House surveys using the total station was 1:7634 and 1:4425, respectively. The survey at Hamm Creek Estuary included the intertidal area of the creek from a point approximately 5 meters (m) downstream of the confluence of Hamm Creek and the freshwater marsh to the fence forming the lower boundary of the site at the confluence of the Duwamish River. At Herring's House, the survey area included the basin and outlet channel to the Duwamish River. Field surveys included mapping the +12.0 ft MLLW contour and the lowest extent of each site; lower elevations did not reach -2.0 ft MLLW at either Hamm Creek Estuary or at Herring's House. Points were taken along the perimeter of the intertidal area and later connected using Nikon TransIt software. The intertidal area between +12 ft MLLW and the lowest point at the site was calculated with Nikon TransIt software using data from this survey.

In 2001, the intertidal area at each restoration site was mapped using the Trimble GeoExplorer 3 Global Positioning System (GPS) (1-5 m precision for each point with differential correction), by walking a continuous line along the perimeter of the intertidal area, outlined by flags placed at 12 ft.

[2]For informational purposes only. In all instances, use of brand names in this report does not constitute endorsement by the U.S. Government.

MLLW based on tide. In order to determine if a change occurred in the intertidal area from 2001, Hamm Creek Estuary and Herring's House restoration sites were also mapped using GPS in winter 2002. GPS surveys at both sites were performed in a similar manner, with the same upland and shoreline boundaries of the site used in 2001 and 2002. The data points were downloaded, differentially corrected, and stored in Geographical Information System (GIS)/ArcView software. The results from GPS were compared to the area values calculated by Total Station in 2002. GPS results from 2002 were also compared to the GPS area calculations from the previous year.

Results

The intertidal area of the Hamm Creek Estuary restoration site in 2002 was 3,005 m^2 (0.7 acres) as measured with Total Station. The elevation of the fence line at the lower boundary of the site was approximately 7 ft (2.1 m). Using GPS in 2002 the intertidal area of the site was 3,278 m^2 (0.8 acres), a value greater than the previous year's intertidal area (2,833 m^2 or 0.7 acres), which was also mapped and estimated using GPS.

At the Herring's House restoration site, the intertidal area was 8,582 m^2 (2.1 acres) in 2002, using Total Station. The survey included the intertidal basin and part of the estuarine channel which connects the basin to the Duwamish River. The lowest point surveyed at the site was 5.0 feet (1.52 m), and was located within the intertidal basin, $\leq$16.40 feet (5 m) north of the channel's opening. With GPS the intertidal area of the site was 8,737 m^2 in 2002. This is greater than the intertidal area (8,449 m^2, or 2.1 acres) measured using GPS at the site in 2001.

Discussion

In 2002 at each restoration site, the intertidal area estimate provided by Total Station survey data was less than the respective site's GPS intertidal area estimate. The observed differences between the Total Station and GPS estimates, 273 m^2 and 155 m^2, are small enough to be within the random error of the measurements, obscuring detection of small changes in area. Based on GPS measurements, there appears to have been a small increase in intertidal area at both sites since 2001. The 20-percent increase (545 m^2) in intertidal area at the Hamm Creek Estuary indicates that a change has probably occurred in the intertidal area between 2001 and 2002. This could be due to subsidence or the amount of erosion that took place at the site. At the Herring's House site only a five percent increase of 288 m^2 occurred which is not so large as to be outside the range of random error. Changes in intertidal area cannot be assessed with the Total Station at either site until next year, and small fluctuations at either site may occur in the future. These fluctuations may be due in part to minute differences in survey techniques, equipment error, or to small changes in the sites as they equilibrate.

Tidal Regime (Physical Success Criterion 2) *Tidal amplitude, as determined by both timing and elevation of high and low tide events, is equivalent inside and outside of the project area.*

Methods

Continuously-recording tide gages (Global Water Level Loggers) were installed within the Hamm Creek Estuary and Herring's House restoration sites to monitor tidal timing and magnitude (precision: 0.2% overall, 0.1% linearity). Tide gages were also placed in the Duwamish River, adjacent to each restoration site, to record tidal stage simultaneously for comparison. Tide gages recorded data for two complete tidal cycles, over a 24-hour period. Tidal-stage data were collected on June 4-5 (average tide) and November 5-6, 2002 (spring tide).

Results

All data collected from both the Hamm Creek Estuary and Herring's House sites indicate that tidal exchange between the restoration sites and Duwamish Estuary continues to remain unimpeded (Figure 4).

Discussion

The timing and magnitude of the tidal cycles recorded thus far have been virtually the same. Adequate tidal exchange between the restoration sites and the Duwamish River allows flushing of the sites, which facilitates the movement of nutrients and sediments between the site and the main river channel. Increased colonization of the sites by aquatic invertebrates and desirable marsh vegetation species may also occur more easily with sufficient tidal exchange, and salmonids and other fish will continue to access and utilize the restored estuarine habitat.

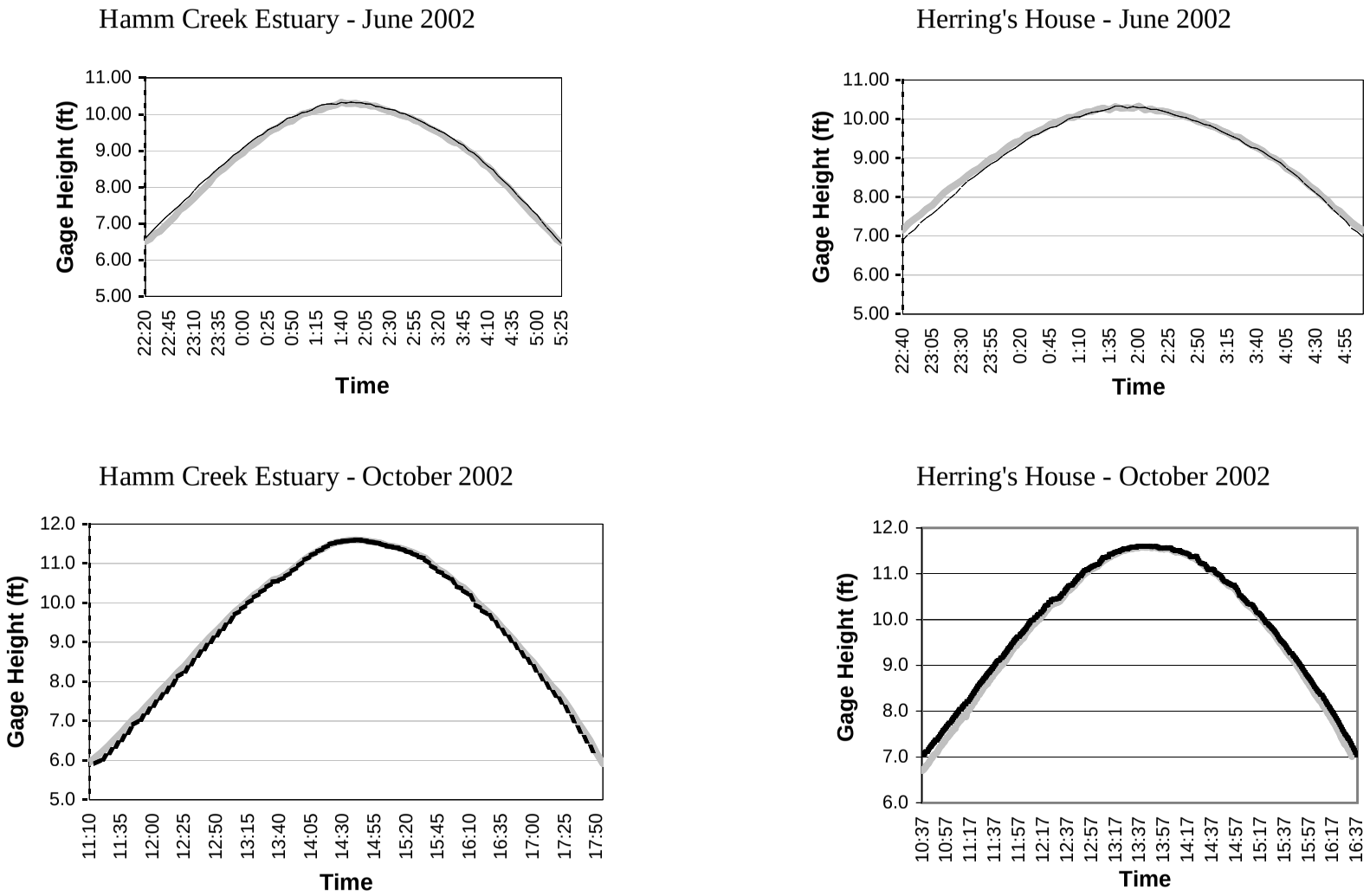

Figure 4. Tidal regime at Hamm Creek Estuary and Herring's House restoration sites (black line) and in the mainstem Duwamish River adjacent to the restoration sites (gray line), June 4-5 and October 5-6, 2002.

Slope Erosion (Physical Success Criterion 3) *No evidence of erosion that threatens property, infrastructure, or is otherwise unacceptable, is observed after a period of initial site stabilization.*

Methods

During site visits, visual inspections were made to determine any obvious bank erosion. Areas with noticeable erosion were identified and additional data were collected during Total Station surveys. These preliminary surveys were performed to serve as a basis for any future efforts to map loss of sediments in problem areas (i.e., Hamm Creek Estuary). Photographs of the sites were also taken periodically during the year to compare erosion over time.

Results

During the previous year, the Hamm Creek Estuary restoration site experienced significant erosion of the instream channel. A topographic survey with a Spectra-Physics® Laserplane 500 laser level was completed just prior to the onset of this erosion in 2001, and data from the survey has been stored in GIS/ArcView software for further analysis. Since that time sediments at the Hamm Creek Estuary have continued to erode, most noticeably along the north bank of the creek near its confluence with the Duwamish River (Figure 5).

The Herring's House site has remained stable since construction was completed. No obvious bank erosion is evident at the site.

Figure 5. View of eroding bank of Hamm Creek Estuary, Duwamish River, looking east, in fall 2002. Note hanging fence posts.

Discussion

While Herring's House appears to be stable, erosion continues to be a concern at the Hamm Creek Estuary. Most of the erosion appears to be occurring in the intertidal area on the northern side of the creek, downstream of where it begins to flow parallel to the mainstem Duwamish River. The most noticeable movement of sediments is located on the northern bank of the lower mouth of Hamm Creek, where much of the subsurface wood and other materials (presumably placed during construction to stabilize the sediments on the peninsula) have become exposed. Efforts to stabilize the area, including placement of cobble, boulders, and large woody debris, were made in 2001 by U.S. Army Corps of Engineers. Cobble (64-256 mm) and boulders (>256 mm) were placed within the mouth of the channel along with four pieces of large woody debris (base diameter approximately 70 cm) with rootwads (Figure 6). These attempts to prevent further erosion have not corrected the situation. In October 2002, rebar was installed for elevation surveys on the northern shore of Hamm Creek, near 12.0 ft MLLW; by December 2002, the sediment level adjacent to the rebar had dropped by approximately one inch. By fall 2002, continued erosion of sediments had dislodged one of the fence posts along the northern shore of the mouth of Hamm Creek, and further erosion may soon threaten the integrity of the goose exclusion barrier. The erosion at the site has been documented by photography in 2001 and 2002. Preliminary Total Station elevation surveys were initiated and may be continued in the coming year based on need and available resources.

Figure 6. Placement of large woody debris, boulders and cobble in the Hamm Creek Estuary, Duwamish River, in 2001.

Sediment Structure (Physical Success Criterion 4) *Over time, sites will accumulate fine-grained material and organic matter. This would be evidenced by a decrease in mean grain size, and an increase in organic carbon in surface sediments.*

Methods

Sediment samples for grain-size analysis and total organic carbon (TOC) were collected on October 15, 2002, at the Hamm Creek Estuary and Herring's House restoration and reference sites. Six 3-inch diameter PVC plastic cores taken to a depth of 10 cm were collected in the intertidal area at each site. Because of the importance of grain size and organic content to benthic invertebrate colonization (Cordell et al. 1999), the sample locations corresponded to the same habitat strata as invertebrate core sampling (Biological Success Criterion 8). Six sediment samples were collected at the Hamm Creek Estuary in the lower intertidal zone. As with the invertebrate surveys, samples were not stratified by vegetation and elevation at this site, due to the influence of the freshwater creek present in the lower intertidal zone. With the freshwater creek flowing over part of the site during low tide, the invertebrate community is substantially different from the brackish community of the reference area (J. Cordell, University of Washington, personal communication 2002).

At the Herring's House restoration and reference sites, core sampling was stratified by vegetated (3 samples per site, +10 ft MLLW and above) and unvegetated (3 samples per site, +9 ft MLLW and below) areas, corresponding to habitat strata of invertebrate core sampling. In 2002, sample areas without vegetation in the +9 ft MLLW zone were difficult to find at the Herring's House restoration site due to the presence of brass buttons (*Cotula coronopifolias*), a nonnative plant species which has colonized much of the lower intertidal basin at Herring's House.

All sediment samples were sent out to a contracted lab for analyses. Results were evaluated to determine whether grain size and organic matter increased or decreased at each site. A decrease in grain size would be indicated by decreasing percentages of sand and increasing percentages of silt and clay. An increase in organic matter would be indicated by increasing TOC percentages.

Results

At the Hamm Creek Estuary restoration site, grain size decreased from 2001 to 2002 (Table 2). At the reference site, there was an increase in grain size. Mean percent TOC values decreased slightly (-0.2%) at both the restoration and reference sites in 2002. In both 2001 and 2002, mean percent TOC values were similar between the restoration and reference sites, and all TOC values during those years were less than 1% (Table 2).

From 2001 to 2002, grain size decreased in the vegetated areas at the Herring's House restoration site, but remained the same in the unvegetated area of the site. At the reference site, the reverse was observed: grain size remained the same in the vegetated areas, but decreased in the unvegetated areas. Percent TOC values for the vegetated areas increased slightly (+0.8%) at the Herring's House restoration site, but decreased (-2.4%) in the unvegetated areas. At the reference site, percent TOC decreased in both the vegetated (-1.6%) and unvegetated areas (-1.0%). In 2001 and 2002, TOC values at the Herring's House restoration site were greater ($\geq$3.4, vegetated; $\geq$0.4 unvegetated) than the corresponding values at the reference site. Detailed results from analysis of TOC and sediment grain size distribution are included in Appendix 1.

Table 2. Mean percent total organic carbon (TOC) and mean percent composition by grain size for Hamm Creek Estuary and Herring's House restoration sites and corresponding reference sites, in 2001 and 2002.

	Mean Grain Size							
	Sand (%)		Silt (%)		Clay (%)		TOC (%)	
Site	**2001**	**2002**	**2001**	**2002**	**2001**	**2002**	**2001**	**2002**
Hamm Creek Estuary	64	54	30	38	6	8	0.9	0.7
Hamm Reference	83	90	14	7	4	4	0.8	0.6
Herring's House								
Vegetated	78	70	17	23	5	8	5.9	6.7
Unvegetated	79	79	15	15	6	6	4.1	1.7
Herring's Reference								
Vegetated	92	93	4	3	4	4	2.5	0.9
Unvegetated	80	55	15	36	4	9	2.3	1.3

Discussion

According to this criterion, successful restoration is demonstrated by an accumulation of fine-grained material and organic matter, indicated by decreasing grain size and increasing total organic carbon, respectively. Estuarine habitats with fine-grained sediments and organic matter support the formation of a detritus-based food web necessary for benthic invertebrates, fish, and other wildlife of special interest to this project (EBDRP 2000). In part, grain size influences the assemblage of benthic invertebrates, and organic matter influences the quality and quantity of food available for invertebrates (Cordell et al. 1999).

The Hamm Creek Estuary restoration site experienced a decrease in grain size from 2001 to 2002, but no change in TOC. While mean percent grain size decreased at the Hamm Creek Estuary restoration site, the reference site experienced an overall increase in grain size. Grain size at the reference site may have increased due to erosion at the restoration site (three of the six sediment samples were collected downstream of the mouth of Hamm Creek). The TOC values for 2002 were less than 2001 values by 0.2% at each site; however, percent TOC was similar between the restoration and reference sites, differing by 0.1% in both 2001 and 2002. These changes cannot be viewed as statistically significant due to the small sample size and variability of the samples. A March 1995 pre-restoration study near Herring's House collected sediment data in which a TOC value of 2.79% was reported (U.S. Army Corps of Engineers 1995). According to the report, this value was sufficient to support benthic organisms. Although the values at the Hamm Creek Estuary restoration and reference sites are below 2.79%, benthic invertebrates are present at the sites. To date, we have not located any further information on favorable TOC levels for benthic organism

establishment or its effects on food availability in the Duwamish River. Trends and changes will continue to be monitored within the limits of the survey protocol.

The Herring's House restoration site also met part of the criterion in 2002. Sediment structure analysis at the restoration site indicated a decrease in mean grain size in the vegetated areas from 2001, but no change occurred in the unvegetated areas in the same time period. In the reference area, grain size was similar to the previous year's surveys in the vegetated areas, but decreased from 2001 to 2002 in the unvegetated areas. Percent TOC was similar between the restoration and reference sites, differing by $\leq$0.4% in both survey years. Several of the mean TOC values at Herring's House were greater than or similar to the results of the March 1995 study mentioned above (U.S. Army Corps of Engineers 1995). Although the results from the sediment structure analysis provide some indication of the degree of the accumulation of fine-grained material and organic matter at the site, the sample size is small (3 samples/area). Because of this limitation, samples may not adequately characterize the site, and this is illustrated by the variability of some of the grain size and TOC samples (see Appendix 1). Another factor at the Herring's House restoration site which may also cause some difficulty in site characterization in the future is the presence of a nonnative plant, brass buttons, which has begun to colonize most of the mudflat area at the site, making it difficult to randomly select sample collection locations in unvegetated mudflat areas.

Samples collected within each site's habitat strata often had highly variable grain size and TOC percent values (Appendix 1). No large changes in mean percent values of silt, clay, or sand were detected. As a result of the small sample size of each habitat stratum ($n \leq 6$), the data cannot determine any statistically significant differences at the sites. The sample size in each habitat sample should be increased to a minimum of 10 samples to better characterize the sites. In addition, some of the individual samples were determined to be too small to effectively analyze grain size when large amounts of vegetation (i.e. roots) were present in the samples; we propose that larger samples should be collected in the future to overcome this problem.

Sediment Quality (Physical Success Criterion 5) *No evidence of contamination due to sediment transport or on-site migration of upland contaminants to groundwater or aquatic areas.* (Herring's House only.)

Methods

Visual inspections were made at the Herring's House restoration site during most field surveys to assess if riprap and/or soils remained stable as compared to the as-built surveys. Photo points were used to compare any yearly changes.

Results

No noticeable migration of riprap or soils occurred at the Herring's House site.

The Washington State Department of Ecology has issued a voluntary cleanup order for this site, requiring installation of three groundwater monitoring wells for compliance purposes (C. Tanner,

USFWS, personnel communication). As of December 2002, groundwater monitoring wells have not been installed at the Herring's House restoration site.

Discussion
Soils and riprap at the Herring's House restoration site appear to have remained stable this year, when compared to the as-built map for the site. No movement of sediments has been observed. Monitoring wells have not yet been installed, although discussions by the City of Seattle with the EBDRP Panel have been ongoing (Curtis Tanner, USFWS, personal communication 2002).

BIOLOGICAL CHARACTERISTICS

Marsh Vegetation Establishment (Biological Success Criteria 1-3) *The areal extent of vegetation should be stable or increasing (Criterion 1), species composition of native wetland plants should be comparable to appropriate reference sites (Criterion 2) and plant vigor should be comparable to appropriate reference sites (Criterion 3).*

Methods
1. *Marsh Vegetation Area*

1.1 Areal Extent
Marsh vegetation was surveyed at the Hamm Creek Estuary and Herring's House restoration and reference sites in summer 2002. The extent of marsh vegetation was mapped using GPS, and an area estimate was calculated for each site using GIS/ArcView software. During 2002 sampling, the extent of marsh vegetation at Herring's House was measured before Hamm Creek Estuary, and included two different GPS methods. The first method ("point method") consisted of a series of points ($\geq$120 positions averaged per point) recorded along the marsh vegetation boundary at each site ($\leq$3 m per point with differential correction). The points were then connected by a line using GIS/ArcView, and an area estimate was calculated. The second method ("polygon method"), also used in 2001 at both sites, consisted of walking a line along the marsh vegetation boundary, continuously recording positions to form the perimeter of a polygon, then calculating the resulting area ($\leq$4 m per position with differential correction), using GIS/ArcView software. When intertidal area was measured at Hamm Creek Estuary, only the first method was used; the precision was believed to be better with this method due to the larger number of positions taken per averaged point.

1.2 Marsh Vegetation Patches
Individual marsh vegetation patches (Lyngby's sedge and bulrush) were measured to the nearest 0.1 m, using a measuring tape and a laser range finder to estimate total area of the patches at each site. This method differed from the previous year, in which GPS was used to estimate the area of individual marsh vegetation patches. Because the areas of some of the vegetation patches were too small to be effectively measured with the resolution of the GPS equipment, the direct measurement was deemed to be a better method for this parameter. The difference in sampling methodology does

not allow for a direct comparison of marsh vegetation areas between 2001 and 2002. In order to establish some level of comparison between the two methods, patch areas at the two marsh vegetation reference sites were measured using both methods. The measurements were then compared at each site.

2. *Species Composition*
Vegetation surveys for species composition occurred along the same transects (Figures 7a, b) as in the previous year, with one exception. At the Hamm Creek Estuary restoration site, part of transect two was replaced by a new transect (Transect 4), due to difficulties in locating two of the previous year's transect turning points.

Species composition was determined by placing 0.25 m^2 quadrats at several points along each transect and each quadrat was placed in the same approximate location ($\leq$ 1 m) as in the previous year. This repetition of placement from 2001 was considered important, particularly in transects 1 and 3, due to the presence of relatively large expanses of bare mudflat with small, scattered patches of vegetation. Plots in the same locations as the previous year would better characterize vegetation growth from year to year, due to the large amount of bare ground present along much of the shoreline in this area[3]. All plant species observed within the quadrats were recorded, and the respective percent coverages were visually estimated.

The monitoring plan specified that the restoration site should not contain greater than 10% cover by area of nonnative or invasive plant species. While the plan focused on several species that could be problematic, specifically cordgrass (*Spartina* spp.), purple loosestrife (*Lythrum salicaria*), reed canarygrass (*Phalaris arundinacea*), and common reed (*Phragmites communis*), all other nonnative and invasive species were also included in percent cover estimates of nonnative species.

[3]In 2001, plots were randomly placed along transects, and quadrats were located on both bare ground and in vegetated areas.

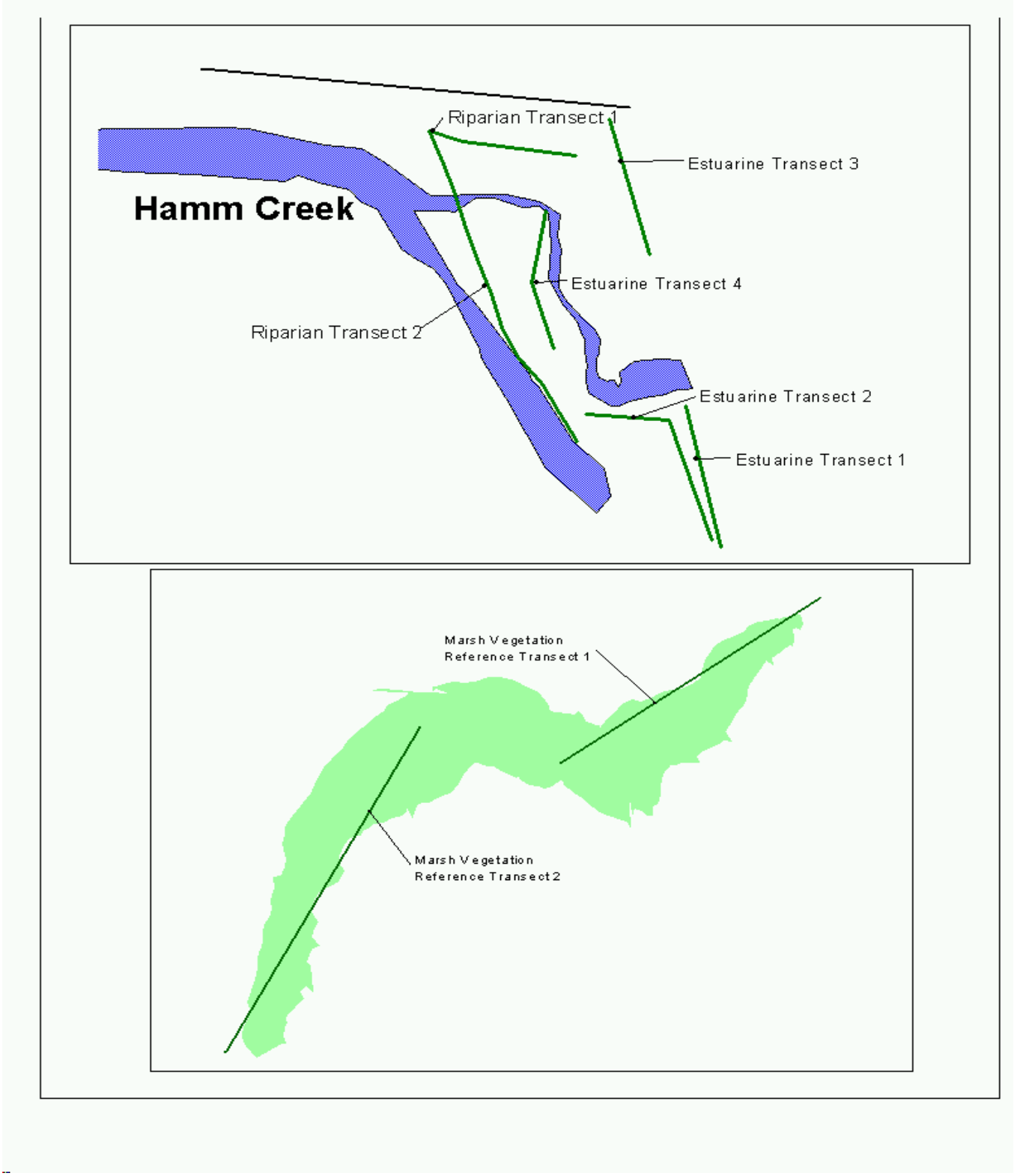

Figure 7a. Placement of vegetation transects at the Hamm Creek Estuary restoration (top) and reference (bottom) sites, in 2001 and 2002.

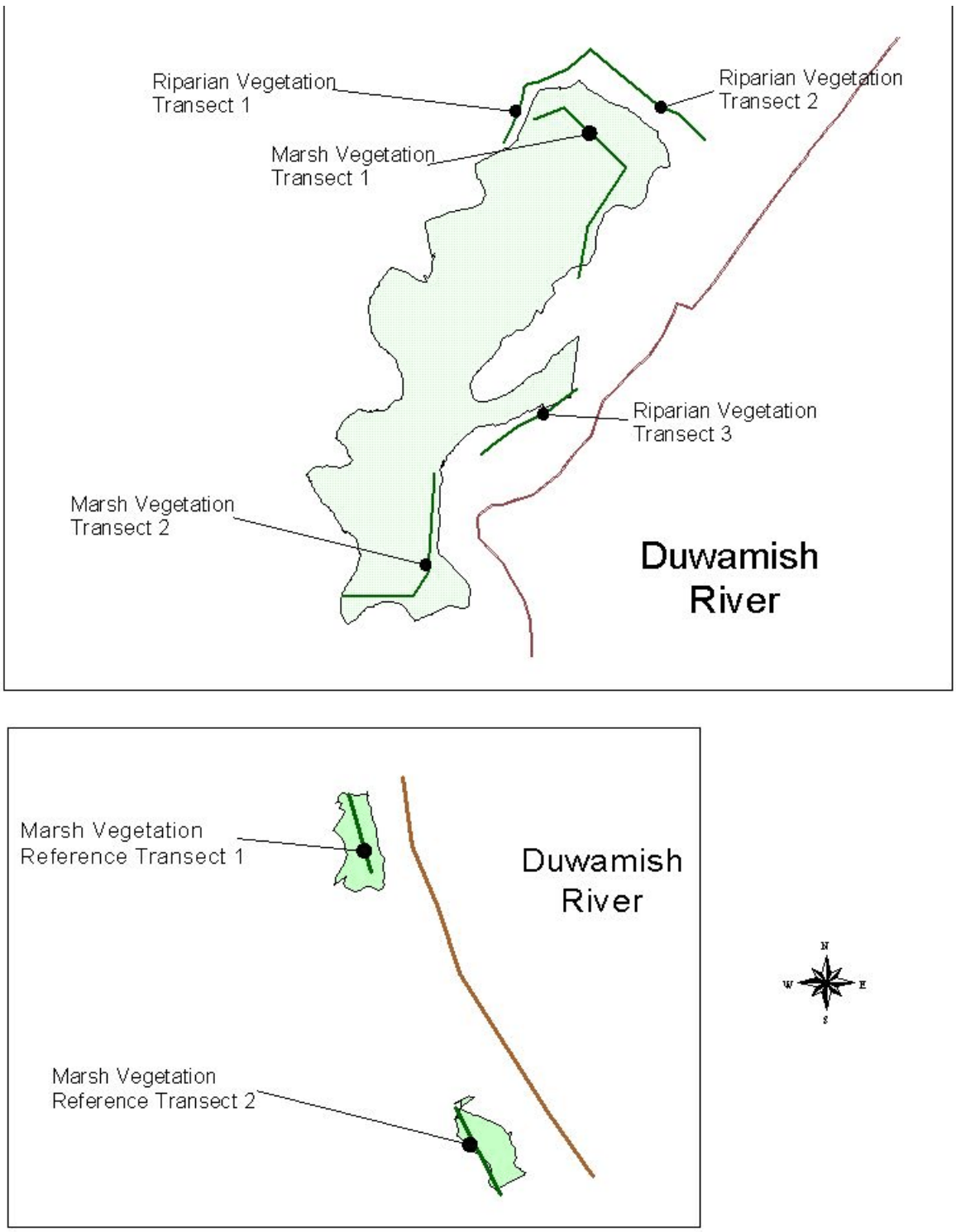

Figure 7b. Placement of vegetation transects at the Herring's House restoration (top) and reference (bottom) sites, in 2001 and 2002.

3. *Plant Vigor*

For the plant vigor criteria, shoot height and density of the target species, Lyngby's sedge and bulrush, were measured within the quadrats. The heights of the three tallest shoots of each species were measured to the nearest cm. Differences in mean maximum shoot heights between the restoration sites and their respective reference sites were determined using a t-test (Zar 1999). Shoot density was determined by counting the number of shoots for each species. Differences between restoration sites and their respective reference sites were examined by using a Mann-Whitney U test (Zar 1999) for comparing two means with non-normal distribution.

Results

1. *Marsh Vegetation Area*

1.1 Total Areal Extent

The total areal extent of marsh vegetation (using the GPS point method) for the Hamm Creek Estuary restoration site in 2002 was 2,211 m^2 (0.6 acres). For the Herring's House restoration site, the total areal extent of marsh vegetation was 8,737 m^2 (2.2 acres). No marsh vegetation areal extent information is available for the Hamm Creek Estuary or Herring's House restoration sites in 2001; only patches of Lyngby's sedge and bulrush were mapped with GPS in 2001.

The total areal extent of marsh vegetation (using the GPS point method) at Herring's House was assumed to be the same as the site's intertidal area (8,737 m^2, using GPS), as reported in Physical Success Criterion 1. The entire intertidal basin of the Herring's House restoration site was included in the marsh vegetation areal extent estimate due to the presence of a nonnative plant (brass buttons) which colonized most of the estuarine basin by summer 2002. The value for the areal extent of marsh vegetation is overestimated, however, due to the absence of brass buttons in the channel and in small patches of mudflat which were too small to measure using GPS (because of the resolution of the equipment).

1.2 Marsh Vegetation Patches

The total area of marsh vegetation patches (Lyngby's sedge and bulrush) measured at the Hamm Creek Estuary restoration site in 2002 was 1,051 m^2. At the reference site, the area of marsh vegetation patches was 622 m^2. The respective vegetation areas at each site in 2002 are greater than in 2001 (450 m^2, restoration site; 537 m^2, reference site[4]).

At the Herring's House site, total area of marsh vegetation patches (Lyngby's sedge and bulrush) was 279 m^2 in 2002. The total area of marsh vegetation patches at the reference site was 65.3 m^2 in 2002. Marsh vegetation areas in 2001were 342 m^2 at the restoration site, and 100 m^2 at the reference site).

[4]Value incorrectly reported in previous year's report (Low and Myers 2002).

2. *Species Composition*

The number of understory vegetation species observed in plots at the Hamm Creek Estuary restoration site was similar between 2001 (20 species) and 2002 (19 species) (Table 3). The numbers of understory species at the Hamm Creek Estuary reference site were also similar between years, but the number of species was lower (five and seven species, respectively) than at the restoration site.

The estimated percent cover of the understory species at the Hamm Creek Estuary restoration site was similar between years, but decreased at the reference site (Table 3). For the target species at the restoration site, estimated percent cover increased from 2001 to 2002. At the reference site, estimated percent cover of the target species was similar to the previous year.

Table 3. Estimated mean percent cover of target species, Lyngby's sedge (*Carex lyngbyei*) and bulrush (*Scirpus* spp.), and the understory vegetation species present in marsh transects at Hamm Creek Estuary (HCE) and Herring's House (HH) restoration and reference sites.

Site	Number of understory species		Estimated % cover of marsh vegetation[1]			
			Understory species		Target species	
	2001	2002	2001	2002	2001	2002
HCE Restoration	20	19	47	51	17	28
HCE Reference	5	7	26	16	78	82
HH Restoration	6	4	35	80	7	7
HH Reference	6	10	52	55	31	19

[1]Each site's percent cover was estimated by averaging the percent cover values in each plot surveyed at the site. Understory and target vegetation species' percent cover were estimated separately.

The estimated percent cover of the understory species at the Hamm Creek Estuary restoration site was similar between years, but decreased at the reference site (Table 3). For the target species at the restoration site, estimated percent cover increased from 2001 to 2002. At the reference site, estimated percent cover of the target species was similar to the previous year.

Although the number of understory species decreased at the Herring's House restoration site, the estimated percent cover of understory species at the Herring's House restoration site increased dramatically from 2001 to 2002. At the reference site, the number of understory species increased, but the percent cover remained the same. For the target species, the estimated percent cover remained the same at the restoration site during the same time period, but decreased at the reference site.

3. *Plant Vigor*

Hamm Creek Estuary (Shoot height and density)
Mean shoot heights of the target species were significantly greater at the Hamm Creek Estuary reference site ($t = -5.6$, $df = 67$, $P < 0.05$, Lyngby's sedge; $t = -10.6$, $df = 6$, $P < 0.05$, bulrush) than at the restoration site in 2002 (Table 4). Mean shoot height of Lyngby's sedge differed from 2001 to 2002 at the restoration site (decrease of 6 cm) and reference site (increase of 14 cm). Similarly, mean shoot heights of bulrush decreased at the restoration site (by 8 cm) and increased at the reference site (by 37 cm).

In 2002, mean shoot densities of Lyngby's sedge were significantly greater ($U = 202$, $CV = 188$, $P < 0.05$) at the Hamm Creek Estuary reference site than at the restoration site (Table 5). Mean shoot densities increased from 2001 to 2002 in both the restoration and reference site sample plots. Mean shoot densities of bulrush at the restoration and reference sites were similar in 2002 and were identical to those at the respective sites in 2001 surveys.

Herring's House (Shoot height and density)
In 2002, mean shoot height of Lyngby's sedge could not be calculated at the Herring's House restoration site, due to the absence of the species in transect plots. The mean shoot height of bulrush was significantly greater ($t = -13.0$, $df = 40$, $P < 0.05$) at the Herring's House reference site than at the restoration site in 2002. Mean shoot height at the restoration site decreased from 61 cm (2001) to 48 cm (2002), but increased at the reference site from 143 cm (2001) to 153 cm (2002).

The mean shoot density comparison for Lyngby's sedge between the Herring's House restoration and reference sites was statistically significant only because Lyngby's sedge was not present in any sample plots at the restoration sites (Table 5). Although no mean shoot density comparison of Lyngby's sedge could be made between years at the restoration site, the mean density at the reference site in 2002 remained the same as in 2001 (Table 5). Mean shoot densities of bulrush were similar ($U=108.5$, $CV=145$, $P<0.05$) at the restoration and reference sites in 2002. At the restoration site, mean shoot density of bulrush increased between 2001 and 2002, but was similar between years at the reference site.

Table 4. Comparison of mean shoot heights of target marsh vegetation species, Lyngby's sedge (*Carex lyngbyei*) and bulrush (*Scirpus* spp.), during vegetation sampling at Hamm Creek Estuary and Herring's House restoration and reference sites, in 2001 and 2002.

	Year[1]	Site	Shoot height			s[2]	n (shoots)
			Mean (cm)	Min (cm)	Max (cm)		
Lyngby's sedge							
Hamm Creek	2001	Restoration	**96**	45	177	38	18
Estuary		Reference	**129**	48	190	40	30
	2002	Restoration	**90**	26	169	40	39
		Reference	**143**	85	205	37	30
Herring's	2001	Restoration	**26**	5	50	13	29
House		Reference	**76**	65	90	8	12
	2002	Restoration	***No analysis performed (Carex absent from plots)***				0
		Reference	87	45	104	17	12
Bulrush							
Hamm Creek	2001	Restoration	**72**	20	118	30	18
Estuary		Reference	**148**	56	200	47	8
	2002	Restoration	**64**	49	87	10	11
		Reference	**185**	152	215	27	6
Herring's	2001	Restoration	**61**	55	65	6	3
House		Reference	**143**	70	215	50	14
	2002	Restoration	**48**	20	113	24	27
		Reference	**153**	111	193	28	15

[1] Shoot height data from 2001 was reanalyzed in 2002 after a few minor errors were observed. The corrected data is shown above and replaces the values reported in Low and Myers (2002).

[2] "s" indicates standard deviation.

Table 5. Mean shoot densities of Lyngby's sedge (*Carex lyngbyei*) and bulrush (*Scirpus* spp.) and statistical analyses for Hamm Creek Estuary and Herring's House restoration and reference sites during marsh vegetation sampling, in 2001 and 2002. An asterisk indicates a significantly higher density value for the reference site (Mann-Whitney test, $P < 0.05$).

	Year[1]	Site	n		Shoot Density			*Details of Analysis*[2]			
			Shoots	Plots	Mean	Min	Max	*s*	*R*	*U*	*CV*
Lyngby's sedge											
Hamm Creek Estuary	2001	Restoration	130	24	**5**	0	39	11	345	219	188
		Reference	155	11	**14***	0	30	10	275.5		
	2002	Restoration	218	24	**9**	0	57	16	362	202	188
		Reference	251	11	**23***	0	42	15	268		
Herring's House	2001	Restoration	70	20	**4**	0	19	5	309.5	100.5	145
		Reference	57	10	**6**	0	17	8	148.5		
	2002	Restoration	0	20	**0**	0	0	0	260	150	145
		Reference	61	10	**6***	0	51	16	205		
Bulrush											
Hamm Creek Estuary	2001	Restoration	28	24	**1**	0	10	3	416.5	147.5	188
		Reference	23	11	**2**	0	18	5	200		
	2002	Restoration	29	24	**1**	0	11	3	430.5	134	188
		Reference	27	11	**2**	0	15	6	199.5		
Herring's House	2001	Restoration	7	20	**0.4**	0	7	2	254	156	145
		Reference	56	10	**6***	0	17	7	199		
	2002	Restoration	70	20	**4**	0	25	6	302	108.5	145
		Reference	46	10	**5**	0	12	5	164		

[1] Shoot density data from 2001 was reanalyzed in 2002 after a few minor errors were observed. The corrected data is shown above and replaces the values reported in Low and Myers (2002).

[2] Abbreviations: s (standard deviation), R (sum of ranks), U (Mann-Whitney statistic), CV (critical value)

Discussion

Total Area Extent

The areal extent of marsh vegetation at Hamm Creek Estuary and Herring's House restoration sites. At both sites the edges of marsh vegetation often extend into the riparian zone. Additionally, most of the intertidal area of the site was included in the marsh vegetation extent at Herring's House because much of the basin is covered by a low-growing cover of scattered vegetation, primarily a nonnative colonizing species (brass buttons). Small patches of bare mudflat in parts of the basin at Herring's House were not large enough to measure using GPS (due to the resolution of the equipment), and, while this plant was present in almost all of the intertidal basin, it was not found in the channel. For these reasons, the areal value of marsh vegetation presented above is likely to be greater than the actual total areal extent of marsh vegetation at Herring's House.

Total areal extent of marsh vegetation was not measured in 2001; therefore, changes in areal extent from 2001 to 2002 could not be calculated. This year's measurements will serve as baseline information for future measurements of the total areal extent of marsh vegetation at the Hamm Creek Estuary and Herring's House sites.

Marsh Vegetation Patches

Different methods were used to measure the total areal extent of vegetation patches in 2001 and 2002. In order to provide an approximation of the change in vegetation patches from 2001 to 2002, an attempt was made to determine (1) change in stand size from 2001 to 2002, as estimated by GPS, and (2) the degree of difference between GPS surveys and direct measurement at sites which had larger stands of vegetation, which are presumably more appropriate for such comparisons, due to their larger size. The largest stands of vegetation occur at both marsh reference sites in the study. The stands at each of the reference sites were measured by using both GPS and direct measurement methods. Comparisons between methodologies at the Hamm Creek Estuary and Herring's House reference sites yield different results (Table 6). When areas of vegetation patches estimated by GPS at the Hamm Creek Estuary reference site are compared between years, the values are somewhat similar, although an increase in area was observed in 2002. When compared to the results of the direct measurement method, however, the GPS values for both years at the Hamm Creek Estuary reference site are less. At the Herring's House reference site, areas of vegetation patches estimated by GPS are similar in 2001 and 2002. The area value estimated by direct measurement, however, is much less than the GPS area values for both years.

Table 6. Comparison of marsh vegetation patch area results using different methodologies, in 2001 and 2002.

Site	GPS (m^2)		Direct measurement	
			Measuring tape (m^2)	Laser range finder (m^2)
	2001	2002	2002	2002
Hamm Creek Reference Site	537*	601	--	622
Herring's House Reference Site	100	91	65	--

** Value incorrectly reported in previous year's report (Low and Myers 2002).*

Although different methods were used in 2001 and 2002, there appears to have been an increase in the total area of marsh vegetation patches since the previous year at both the Hamm Creek Estuary restoration and reference site. At the Herring's House sites, total area of marsh vegetation patches decreased at the restoration site, and stayed the same or decreased at the reference site from 2001 to 2002. The decrease at Herring's House restoration site may have been due, at least in part, to the failure of one section of the goose exclusion fencing, allowing geese to access the site. Although the Herring's House reference site has no goose exclusion, the stands of Lyngby's sedge are more mature, and may therefore be more resistant to the effects of grazing by Canada geese. While the

total area of target vegetation patches may have decreased at Herring's House, estimates of understory species composition and qualitative field observations at the restoration site indicate that the target species and other marsh vegetation species appear to be spreading in the intertidal zone.

This year's direct measurement methods will be used for all future marsh vegetation patch area calculations at Hamm Creek Estuary and Herring's House sites. Direct measurement (±0.1 m, accuracy) is more appropriate than GPS mapping on smaller areas because of the lower resolution of the GPS at this scale. Consequently, 2002 data using the direct measurement methodology will serve as baseline data for future changes in marsh vegetation patch data.

Species Composition

At the Hamm Creek Estuary restoration site, the percent cover and number of understory species was similar in 2002 to the previous year, while the reference site experienced a decrease in percent cover. Percent cover of target species at the Hamm Creek Estuary restoration and reference sites increased from 2001 to 2002, although the increase was more obvious at the restoration site (11%) than at the reference site (4%). At the Herring's House restoration site, the percent cover of understory species was much higher in 2002 than in the previous year, although the number of species decreased slightly. At the Herring's House reference site, numbers of species increased slightly, but the percent cover of understory species was similar to the previous year. The percent cover of target species remained the same at the restoration site from 2001 to 2002, while the reference site experienced a decrease. These results, in addition to qualitative observations at the sites indicate there is improvement in vegetation establishment at the restoration sites, especially when compared to the respective references sites.

Plant Vigor

Plant vigor, as defined by shoot height and density of the target species (Lyngby's sedge and bulrush), was generally better at the Hamm Creek Estuary and Herring's House reference sites than at their respective restoration sites. Mean shoot height of the target species was much lower at the restoration sites than at the corresponding reference sites. Shoot heights for the target species decreased at both restoration sites from 2001 to 2002, while shoot heights of these species at the corresponding reference sites increased. One noticeable difference between 2001 and 2002 was the absence of Lyngby's sedge shoots in the plots at the Herring's House restoration site in 2002. The restoration sites are still in a relatively early stage of development, and patches of vegetation are not expected to be as dense as in the reference site. Consequently, they are still highly vulnerable to grazing by geese. At both Hamm Creek Estuary and Herring's House, there were periods of time (weeks to months) in which goose exclusion devices were not functioning properly. It is likely that some grazing may have occurred before the vegetation surveys, and several cropped plants were observed. Although geese could have been present during part of the year, dabbling ducks could access the sites at all times, but their impacts to the vegetation are unknown.

Riparian Vegetation (Biological Success Criteria 4 and 5) *The areal extent of vegetation should be stable or increasing over time, and cover not less than 90% of the upland vegetated area of each project site at the end of ten years, and invasive plant coverage should be minimal (Criterion 4). Survival of riparian plantings in each cover class (herb, shrub, and tree) should be at least 75% at the end of three years (Criterion 5).*

Methods

Areal Extent
The perimeters of riparian vegetation at each site were mapped using the Trimble GeoExplorer 3 GPS to determine areal extent of riparian vegetation in a similar manner ("point method") as for areal extent of marsh vegetation. During the construction of both restoration sites, most of the area upslope of the marsh was planted with riparian vegetation (shrubs and trees) in a somewhat uniform fashion, with herbaceous plants colonizing the disturbed areas between the plantings. The entire riparian area at each site was included in the areal extent of the Hamm Creek Estuary and Herring's House riparian vegetation zone estimates; however, the riparian and marsh vegetation zones overlapped occasionally at the sites. For purposes of the survey, the riparian vegetation zone included all upland plantings and small, but substantial, patches of riparian vegetation (or individual trees) that extended into the marsh vegetation zone.

Percent Cover of Vegetation Layers
Surveys were conducted in the riparian vegetation zone along the transects established in 2001 (Low and Myers 2000), to assess the percent cover of herbaceous, shrub, and tree layers. Plots were placed along the transects, at randomly-chosen intervals for each transect, and the first plot of each transect was located at a randomly-chosen distance from the starting point. The herbaceous layer was sampled using a 0.25 m^2 quadrat, while the shrub and tree layers were sampled using a 3-m radius circular plot. Percent cover was visually estimated to the nearest 5% for each layer. For each site, mean percent cover values were calculated for all layers.

Nonnative species
Nonnative species were sampled, as a layer, at the same time as were the shrub and tree layers, using a 3-m radius circular plot. Percent cover was visually estimated to the nearest 5% for each layer, and means were calculated in the same manner as the other layers.

The monitoring plan (EBDRP 2000) identified three nonnative species of special concern which might become established at the site: Himalayan blackberry (*Rubus discolor*), Scot's broom (*Cytisus scoparius*), and Japanese knotweed (*Polygonum cuspidatum*). While two of these species (Himalayan blackberry and Scot's broom) were encountered at the sites, there were also other invasive, nonnative species present which were included in the layer's percent cover estimates in each plot.

Survival
Survival of shrubs and trees was determined by comparing the number of dead or dying individuals to the total number of individuals (shrubs and trees) in the percent cover survey plots at each site.

Results

Areal Extent

The total areal extent of riparian vegetation at Hamm Creek Estuary in 2002 was 2,648 m^2 (0.7 acres), a greater value than in the previous year (2,104 m^2 or 0.5 acres). At Herring's House, the areal extent of riparian vegetation in 2002 was 8,706 m^2 (2.2 acres), lower than the previous year's value[5] (9,598 m^2 or 2.4 acres).

Percent Cover of Vegetation Layers

At Hamm Creek Estuary, percent cover of the herbaceous, shrub, and tree layers increased from the previous year's surveys (Table 7). At Herring's House, percent cover for herbaceous and tree layers in 2002 increased from the previous year, while the percent cover for the shrub layer decreased (Table 7). Riparian vegetation species observed at Hamm Creek Estuary and Herring's House restoration sites during 2001 and 2002 surveys are included in Appendix 3.

Nonnative Species

There was an increase in the percent cover of nonnative species at Hamm Creek Estuary from 2001 (4%) to 2002 (18%) (Table 7). Nonnative species present included milkweed (*Asclepias* sp.), Canada thistle (*Cirsium arvense*), bull thistle (*C. vulgare*), Scot's broom, hairy cat's ear (*Hypochaeris radicata*), prickly lettuce (*Lactuca serriola*), rye grass (*Lolium perenne* ssp. *multiflorum*, likely planted as a soil stabilizer), reed canarygrass, Himalayan blackberry, and common tansy (*Tanacetum vulgare*).

The percent cover of nonnative vegetation at Herring's House restoration site increased from 5% to 17%, respectively, in 2001 and 2002 (Table 7). Nonnative species present included: dog fennel (*Anthemis cotula*), butterfly bush (*Buddleja* sp.), Canada thistle, bull thistle, Scot's broom, St. John's wort (*Hypericum* sp.), hairy cat's ear, prickly lettuce, white sweet clover (*Melilotus alba*), reed canarygrass, Himalayan blackberry, evergreen blackberry (*R. laciniatus*), and common tansy.

[5]Value incorrectly reported in previous year's report (Low and Myers 2002).

Table 7. Percent cover of herbaceous, shrub, tree and nonnative riparian vegetation layers at Hamm Creek Estuary and Herring's House during 2001and 2002 surveys.

Site	Year	% Cover of Riparian Vegetation Layers			
		Herbaceous	Shrub	Tree	Nonnative
Hamm Creek Estuary	2001	28	7	11	4
	2002	71	15	25	18
Herring's House	2001	44	27	26	5
	2002	50	16	35	17

Survival

Survival of shrubs and trees at Hamm Creek Estuary was high (≥95%), and total numbers of plants counted increased from 2001 to 2002 (Table 8). At Herring's House, survival was high (>90%) for both shrub and tree layers, and there were over twice as many trees counted in 2002 transect surveys than in 2001 (Table 8). Many of the additional trees counted in 2002 at Herring's House were volunteer seedlings, especially red alder (*Alnus rubra*) and black cottonwood (*Populus balsamifera*), which were numerous in much of the riparian area at Herring's House.

Table 8. Survival of riparian vegetation shrubs and trees at Hamm Creek Estuary and Herring's House during 2001-2002 surveys.

Site	Layer	Number of plants observed		# Dead		# Stressed		Percent survival	
		2001	2002	2001	2002	2001	2002	2001	2002
Hamm Creek Estuary	Shrub	63	100	0	1	0	0	100	99
	Tree	74	101	2	1	5	4	91	95
Herring's House	Shrub	205	231	0	1	0	0	100	100
	Tree	130	273	0	19	0	5	100	91

Discussion

Areal Extent

During construction, shrubs and trees were planted in a fairly uniform fashion throughout the riparian zone of the Hamm Creek Estuary and Herring's House restoration sites; as a result, the entire riparian zone has been included in each site's riparian areal extent estimates in both 2001 and 2002. The total areal extent of riparian vegetation in 2002 was different than in 2001 at both

restoration sites. Hamm Creek Estuary experienced an increase of 26% (544 m^2) in riparian areal extent. At Herring's House, the total areal extent of riparian vegetation decreased by almost 9% (892 m^2) during the same time period. The upland boundaries surveyed at each site's riparian zone was the same in 2001 and 2002, but as riparian vegetation spreads into the edges of the intertidal area (below 12.0 ft MLLW), the lower boundary of the riparian zone varied. It is likely that the differences in areal extent of riparian vegetation will continue to fluctuate over time, as the boundaries of the riparian and marsh vegetation zones merge to some degree in the restoration sites. Because of these fluctuations, any minor decrease in riparian areal extent should not be considered problematic at these sites.

Percent Cover of Vegetation Layers

At Hamm Creek Estuary, the percent cover of all riparian vegetation layers increased by over 50% from 2001 to 2002. In fact, both the herbaceous and tree layers are already at or above the projected goal for next year's percent cover estimates (>70% herbaceous, >25% tree, from EBDRP 2000). At Herring's House, percent cover of the herbaceous and tree layers increased in 2002 from the previous year, while the percent cover for the shrub layer decreased. The reason for this disparity is unknown and may depend upon a combination of several factors, including climate conditions such as temperature, precipitation, and soil composition.

Nonnative Species

There was an increase of nonnative vegetation species percent cover at Hamm Creek Estuary in 2002. Two of the four nonnative species identified as especially problematic, Himalayan blackberry and Scot's broom, were present at the site, and their combined percent cover for the site was estimated to be 6%. There were many other nonnative species present which appeared to be colonizing the site. Many of these species have begun to form large stands of vegetation in the riparian zone. When all nonnative species present in the surveys are included, the estimated percent cover of nonnative species at the site is 18%, a value above the target goal for next year's estimate (<10%). There have been observed attempts to remove some of the nonnative species (especially Scot's broom) present at the site. However, many plants are still present and spreading (by seed dispersal or other forms of propagation). If these species continue to proliferate in the site, they may soon begin to compete with preferred, native vegetation for space and other resources. One of the most noticeable examples of invasive, nonnative species at Hamm Creek Estuary is birds-foot trefoil (*Lotus corniculatus*), which has begun to colonize the riparian area in several places, particularly along the intertidal zone at the northern end of the estuary.

At Herring's House, percent cover of nonnative species also increased in 2002, with Himalayan blackberry and Scot's broom, two of the nonnative species mentioned in the monitoring plan (Low and Myers 2001), comprising approximately 4% of the site. When the other nonnative species at the site are considered, nonnative species make up of 17% of the percent cover at the site, which is above the maximum percent cover goal (<10%) for the restoration sites in 2003 (EBDRP 2000). Many of these species have noticeably spread further into the site, with some species beginning to form small stands. Some of these species may need more active control than has been used thus far at the site. Butterfly bush and white sweet clover are among the more obvious examples of nonnative plant species that appear to be spreading rapidly at Herring's House. At their present rate

of colonization, these and other nonnative plant species are likely to become problematic at the sites in the next several years.

One species which was observed in 2002 at both of the Hamm Creek Estuary and Herring's House sites (but not in transects) was perennial pepperweed (*Lepidium latifolium*), a Class B noxious weed in the state of Washington and a designate in King County (Appendix 4). This category of noxious weed requires control of seed production (Lantz and Simon 1998). Seed sources for Hamm Creek Estuary have been observed on the adjacent upstream property (J. Lantor, U.S. Fish and Wildlife Service, personal communication 2002).

Survival

Survival of shrubs and trees was high at the Hamm Creek Estuary site (99% shrubs, 95% trees). However, the survival estimate in relation to site development could be misleading at this stage of the monitoring period, due to the subsequent plantings of trees at the site by other entities (e.g. People for Puget Sound). While these actions are beneficial to the site in the long term, the planting of additional vegetation (e.g. trees) biases survival estimates of this monitoring project. Better estimates could be developed by increasing cooperation with other entities to determine how many trees have been replaced and how often weeding was done in the survey area. This information would enhance the Year 3 surveys and provide better estimates of survival.

Overall, survival of trees and shrubs was high for Herring's House, due to volunteer seedlings and vegetation enhancement and/or replacement by Seattle City Park staff. Several stressed or dead plants, especially red alder and black cottonwood, were observed during vegetation surveys both within and outside of transects at the Herring's House site. Many (if not all) of the dead plants were removed by Seattle City Park staff on the day the vegetation surveys were completed. Maintenance by Seattle City Park staff has been observed, such as plantings and removal of dead plants, although most of the plantings observed by Service personnel occurred in the highly-maintained, park-like section of the site.

Herring's House had a large increase in the number of trees counted within the plots, from 130 trees in 2001 to 273 trees in 2002, with much of the increase likely due to natural colonization at the site. Many young seedlings, predominantly red alder and black cottonwood, were present in the riparian portion of Herring's House. Upon close examination, the seedlings appeared to be propagules of previously planted trees. According to discussions with various City of Seattle and Park Staff, some thinning of alder and cottonwood trees has occurred, although the majority of such actions have occurred in the portion of the site maintained as a public access park and not along transects. Plantings and/or removal of shrubs and trees complicate the survival estimates at the restoration site. If further plantings or thinning will occur in the area of the site which contains the riparian transects (i.e. outside of the public use area), this information should be shared with Service personnel.

In addition to plantings during construction, People for Puget Sound has since been involved in adaptive management at the Hamm Creek Estuary restoration site, enhancing vegetation establishment through plantings (e.g. willow stakes planted along the freshwater marsh shoreline) (Tom Dean, People for Puget Sound, personal communication 2002). Potted trees and shrubs were

also observed by Service personnel in the riparian zone of the site during fall and winter. Although this management will be beneficial to the site in the future, the addition of plants between vegetation surveys may make it difficult to correctly interpret changes in percent cover and survival of riparian vegetation from year to year. While these data have been included in this report, interpretation of the data provided by these surveys must be considered carefully under the present conditions.

Bird Use (Biological Success Criterion 6) *Use of the restoration sites and the area within 50 meters of the site by indigenous/native bird species should be comparable to that of the appropriate reference sites.*

Methods

Bird surveys designed to detect bird presence/absence were conducted quarterly at the Hamm Creek Estuary and Herring's House restoration sites, with surveys at each restoration site performed concurrently with the respective reference site's survey. Three fifteen-minute surveys were performed on the same day at each of the site pairs on March 14, June 10, September 9, and December 5, 2002, with the first survey beginning at sunrise, and at or near high tide. When the initial 15-minute survey was completed for the first site pair, observers then traveled to the next site pair for a survey at high tide. The two remaining surveys for the site pairs were conducted in an alternating pattern, at mid- and low tides (i.e. when the restoration sites were dewatered), respectively.

During the quarterly surveys for presence/absence of birds, additional information was collected for use in detecting trends or changes over time. At each site, observers recorded all birds present, their gender (if known), and their primary behavior. Primary behavior was defined as the behavior exhibited by each bird during most of the observation period. Recorded behaviors included transit (swimming or flying), foraging, breeding/mating, resting/loafing, perching, and other. Birds flying over the site, but not obviously associated with the site, were noted, but were not included in analyses.

Results

At both the Hamm Creek Estuary and Herring's House sites, more bird species were observed in 2002 than in 2001 (Table 9). When the restoration and reference sites are compared, the Hamm Creek Estuary sites had similar numbers of bird species (difference of ≤ 4 species) in both 2001 and 2002. At Herring's House, numbers of bird species were similar (difference of 2 species) between the restoration and reference sites in 2002, but less similar in 2001 (difference of 7 species).

Numbers of species present during surveys at the Hamm Creek Estuary and Herring's House restoration sites and their respective reference sites varied by quarter, with the greatest quarterly difference occurring at the Hamm Creek Estuary sites during the September survey (Table 9). Observations during this quarter noted twice as many bird species at the reference site (30 species) than were found at the restoration site (15 species). For a complete list of birds present at the Hamm Creek Estuary and Herring's House sites, see Appendix 5.